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## Perceptions of Barriers and Benefits of Manure Use in Cropping Systems

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# Perceptions of Barriers and Benefits of Manure Use in Cropping Systems

## Abstract

Animal agriculture is tasked with recycling the nitrogen and phosphorus in manures in an environmentally sound manner, typically as a soil fertility amendment. The increasing complexity of animal agriculture and its feed supply has resulted in significant specialization of businesses often separating production of animals from feed grains and forage production. The recycling of manure nutrients often requires voluntary transfer of manures to crop farms with little or no history of manure in a fertility program. The ability of manure to compete with commercially available fertilizers is essential for this transfer to be considered by crop farmers. A project team engaged in a needs assessment of farmers' and their advisors' perceptions of the benefits of manure use in cropping systems as well as the challenges that could create barriers for such transfers. We learned from those surveyed there exists a strong recognition of manure's fertility, yield, and soil health benefits. However, soil health benefits of manure may be less well understood by farmers compared with fertility benefits. Manure's water quality benefits through soil aggregation and less mobile nutrient forms are not perceived to exist or understood sufficiently for communicating to others. Finally, many challenges associated with manure frequently become barriers to manure use. The group identified four challenges most likely to prevent manure recycling including 1) transportation costs, 2) odor, 3) logistical barriers, and 4) agronomic concerns that will need to be addressed to encourage an expanded role of manure in more cropland.

## Keywords

Animal manure, crop production, manure use survey, manure benefits, manure barriers, farmer perceptions

## Disciplines

Agriculture | Bioresource and Agricultural Engineering

## Comments

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# *Perceptions of Barriers and Benefits of Manure Use in Cropping Systems*

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**Written for presentation at the  
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**ABSTRACT.** *Animal agriculture is tasked with recycling the nitrogen and phosphorus in manures in an environmentally sound manner, typically as a soil fertility amendment. The increasing complexity of animal agriculture and its feed supply has resulted in significant specialization of businesses often separating production of animals from feed grains and forage production. The recycling of manure nutrients often requires voluntary transfer of manures to crop farms with little or no history of manure in a fertility program. The ability of manure to compete with commercially available fertilizers is essential for this transfer to be considered by crop farmers. A project team engaged in a needs assessment of farmers' and their advisors' perceptions of the benefits of manure use in cropping systems as well as the challenges that could create barriers for such transfers. We learned from those surveyed there exists a strong recognition of manure's fertility, yield, and soil health benefits. However, soil health benefits of manure may be less well understood by farmers compared with fertility benefits. Manure's water quality benefits through soil aggregation and less mobile nutrient forms are not perceived to exist or understood sufficiently for communicating to others. Finally, many challenges associated with manure frequently become barriers to manure use. The group identified four challenges most likely to prevent manure recycling including 1) transportation costs, 2) odor, 3) logistical barriers, and 4) agronomic concerns that will need to be addressed to encourage an expanded role of manure in more cropland.*

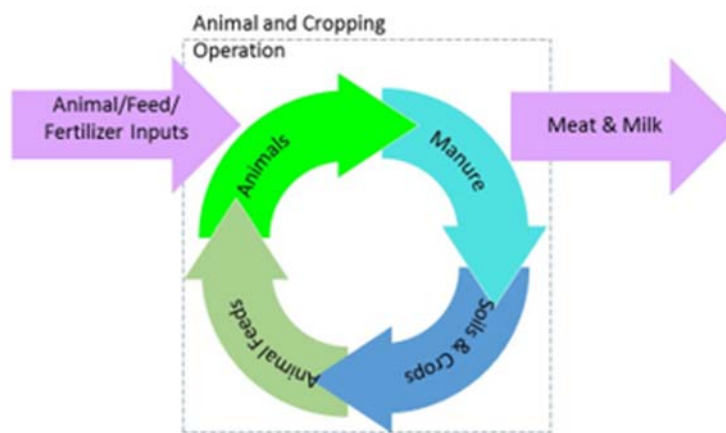
**Keywords.** *Animal manure, crop production, manure use survey, manure benefits, manure barriers, farmer perceptions*

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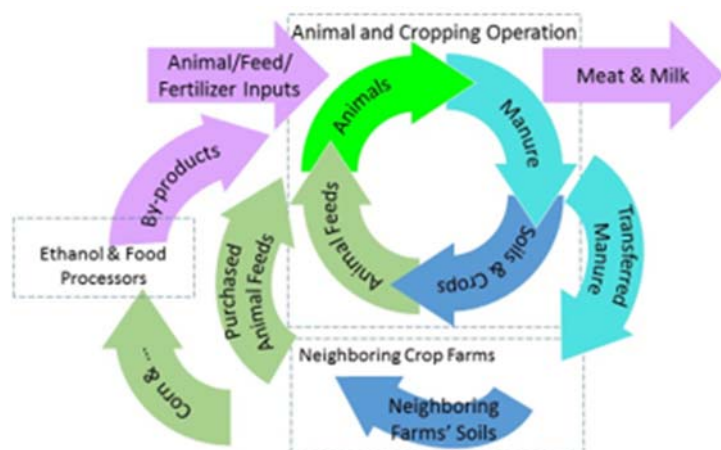
# Introduction

The importance of recycling is strongly encouraged in many industries including agriculture. Many environmental organizations, businesses, and governmental organizations champion the benefits of the “circular economy” for improving sustainability (Butterworth et al., 2014; Kirchherr et al., 2017). The circular economy is contrasted with our traditional linear economy where unlimited raw materials are available, products are manufactured for a single use, and products are discarded as they reach an end to their useful life.

Integration of animal and crop production represents an excellent example of the application of the circular economy to manage nitrogen (N), phosphorus (P) and other nutrients (Figure 1). Agriculture recycles these critical nutrients from animal feed to manure to soils and back to animal feed. Nutrients are added to the farm when animals, feed and fertilizer are purchased (input arrow). These inputs must offset the nutrients leaving the farm as meat and milk (output arrow) as well as any nutrient losses in the system (e.g. nitrogen lost into the air). The efficiency of this nutrient recycling process impacts both the nutrient losses experienced by the agricultural system as well as its economic sustainability.



**Figure 1. Recycling of nutrients is critical to an environmentally sound agricultural “circular economy”.**



**Figure 2. Nutrient additions as animal feeds from outside sources requires recycling of manure nutrients by independent crop farmers to maintain environmental sustainability.**

Management of animal manures in crop production has commonly involved two opposing sentiments. Is manure a “waste” that pollutes our water resources and creates undesirable nuisances for communities? Or, is manure a “resource” that reduces the demand for importing greenhouse gas intensive inorganic fertilizers and improves the health of our soils? Both statements contain some truth. However, the balance of the truth lies in choices made for management of manure.

A faculty team from University of Nebraska, University of Minnesota, and Iowa State University initiated an Extension educational project focused on “How can manure’s benefits be enhanced and undesirable traits minimized relative to its use in cropping systems?”. With the growing need to transfer manure to farms with no recent history of manure use, additional stakeholders including crop farmers, crop advisors, and retail agronomists must be engaged in manure management decisions. The project team identified a needs assessment process involving a stakeholder advisory group and a survey of targeted clientele perceptions of animal manure to better target services and educational needs for expanding manure use into additional cropland. This paper introduces the resulting needs assessment process and survey results.

## Survey Methodology

A project advisory group and related stakeholder conversations pointed us to the need to develop an understanding of the issues most important to potentially new manure users and their advisors as they make fertility decisions, possibly involving manure. While stakeholder conversations identified many important benefits and potential barriers, we agreed future educational programs need to be based upon an understanding of:

- Challenges that regularly prevent manure's use in crop production and
- Those benefits of manure that are not recognized and/or understood.

A survey was developed to answer the above questions with crop farmers, animal feeding operation (AFO) managers, public and private sector advisors for cropping decisions, and Extension professionals. Conversations with The Fertilizer Institute, American Agronomy Society's Certified Crop Advisor program, and the Manure Manager magazine led to their assistance in promoting the survey with a national audience. Within our project team's three states, additional partners were drawn upon to encourage access to the survey with our targeted audiences.

The draft survey was tested with three groups (our stakeholder advisory group, the national Livestock and Poultry Environmental Learning Community, and the Nebraska animal manure management team) leading to the final product. The final product was delivered electronically through Qualtrics<sup>SM</sup> (<https://www.qualtrics.com>) survey application tool using a University of Nebraska-Lincoln licensed product. The current survey tool can be reviewed and completed by visiting <http://go.unl.edu/manure>. The front page of the survey is illustrated in Appendix A. The average time to complete the survey was just under 10 minutes.

The survey included five distinct sections for gathering data from participants.

1. **Participants Role in Manure Decisions:** The first question sorted survey participants by crop producer, animal producer, or advisor in crop fertility decisions. Those who advise were directed to a second question to define their specific services provided – private sector (including independent consultant, retail agronomy services, and others), regulatory services, agency technical services and educational services. Results of these two questions directed different audiences to a pre-defined set of questions.
2. **Participant Demographics:** our questions addressed gender, years of experience, zip code, and frequency with which manure is used in crop fertility plans.
3. **Manure's Benefits:** Perceptions and knowledge of manure characteristic typically perceived as benefits were addressed through a series of three questions. All participants rated the degree to which they considered manure to harmful to beneficial for crop fertility, soil physical characteristics, soil biological characteristics, crop yields, and environmental quality. Using the same five characteristics, all survey participants were asked to rate their own knowledge for each independent characteristic. All those who indicated they provided advisory services in section 1 above were asked to share their perceptions on crop farmers understanding of these five characteristics.
4. **Manure's Challenges:** A series of five questions identified potential challenges that represent frequent barriers (either real or perceived) preventing manure use in crop fertility programs. The five questions shared lists of agronomic, economic, neighbor or rural community, regulatory, and logistical challenges. The intent is to identify higher priority challenges preventing manure's use.
5. **Decision and Education Resources:** The survey concludes with a single question asked separately for farmers, public and private sector service providers, and Extension/education providers asking the types of supporting resources each group is most likely to use.

## Results and Discussion

### Surveyed Participants

Participants in this survey self-selected for adding their ideas and perceptions. Participation was influenced by the organizations, and their targeted clientele, who agreed to assist in promoting the survey and the interest of prospective participants in the topic of using manure in crop production. This voluntary, self-selection approach results in some recognized bias in the survey. There were 1140 survey responses started and 84% were completed (those not identifying as crop farmer, AFO manager, or public or private sector agricultural advisor were not asked to complete survey questions). This paper examines perceptions and attitudes from all responses. Currently, the results are heavily weighted towards

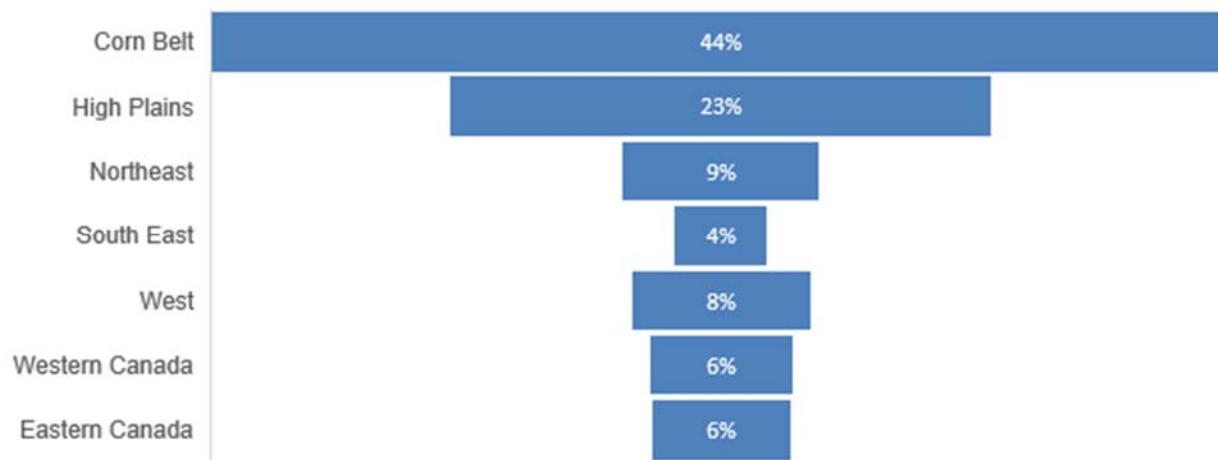


Figure 3. Region of US and Canada represented by survey participants (N= 957).

participants from the Corn Belt and the High Plains regions of the U.S (see Figure 3).

Participants self-identified as a crop farmer, animal feeding operation (AFO), as professionally advising or crop fertility or manure management decisions, or some combination of these three roles (Figure 4a). The assistance received by the American Agronomy Society's Certified Crop Advisor program for advertising this survey contributed to the large representation from those who deliver advisory services. Those responding as professional advisors further defined their advising role (Figure 4b). Those providing retail agronomy products and services (33%) and independent technical services (28%) represented the largest groups of survey responses.

One final observation reveals that our survey responses represent those individuals who have a history of manure use in their crop fertility program management or advising (Figure 5). Those identifying as a farmer (crop farmer or AFO) commonly used manure on some fields annually (73% - Figure 5a). Those identifying as advisors (Figure 5b) suggested that manure management is a primary focus of crop fertility advising (20%) or frequently a part of crop fertility advising (39%). Our survey responses are heavily influenced by those with "real world" experiences of manure utilization and should provide insight relative to the benefits and challenges associated with manure. Our results may not represent those crop farmers or advisors who avoid manure use and their reasons for such avoidance.

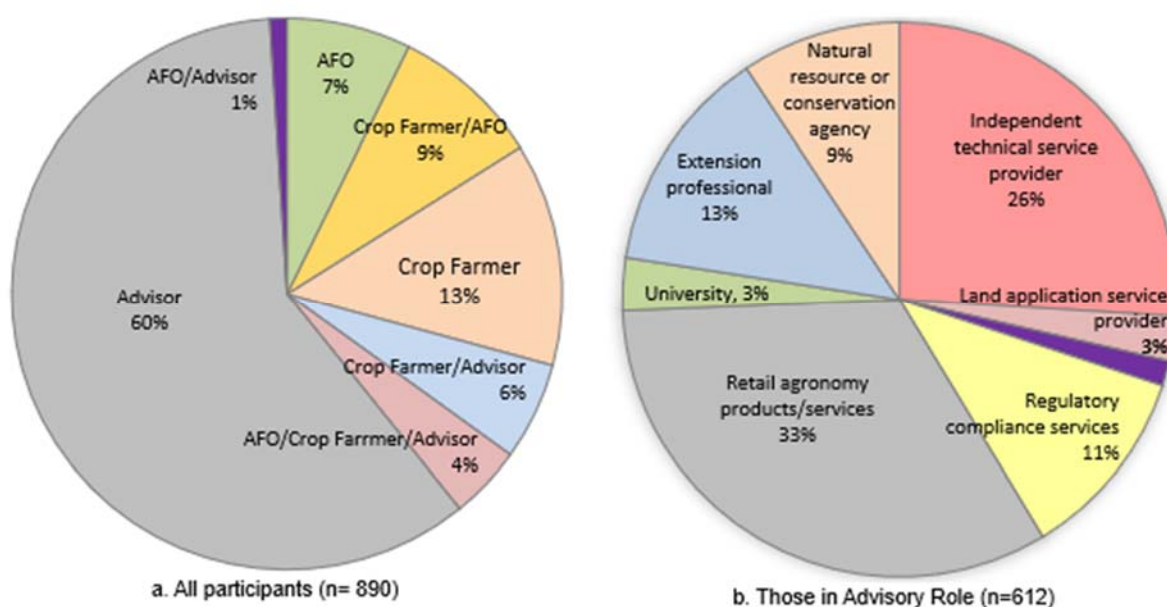


Figure 4 Survey participants role in agronomic decision (n= 890).



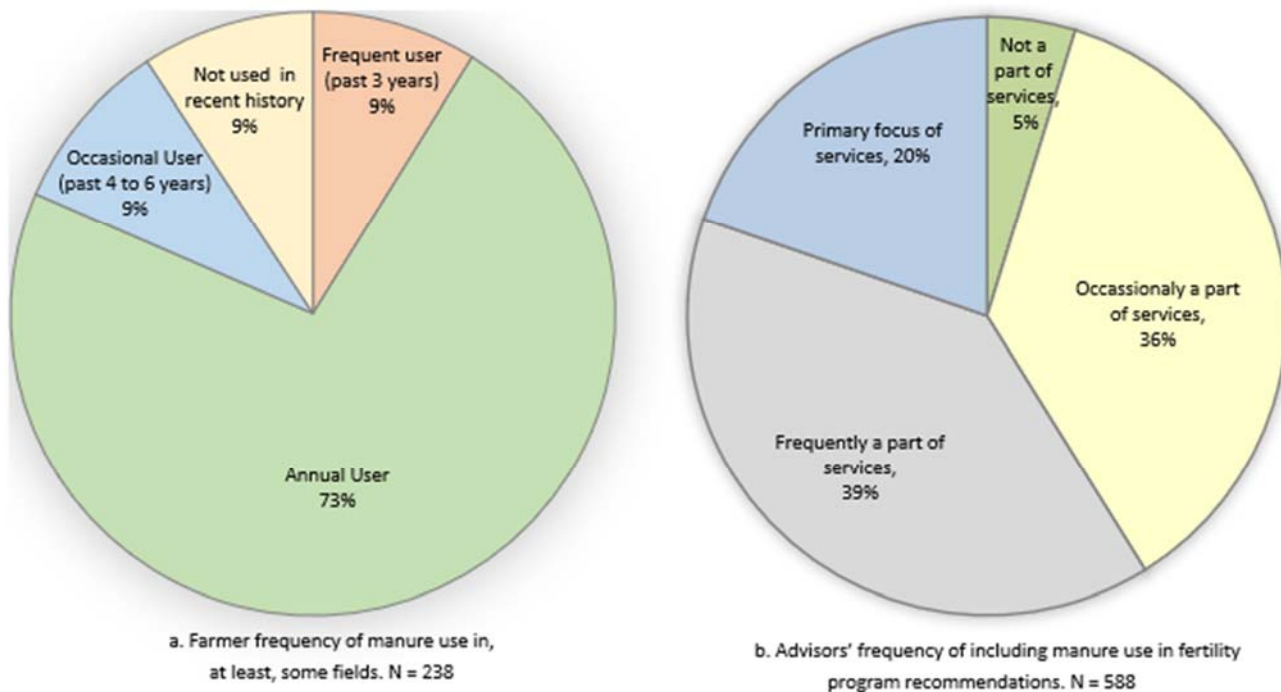


Figure 5. Response by farmers and advisors relative to frequency of manure use in fertility decisions or recommendations.

### Perceptions and Knowledge of Manure's Benefits

Five characteristics identified as “potential benefits” by our project’s stakeholder advisory group were evaluated for survey participants’ perceptions and understanding. Those potential benefits included a) crop fertility and nutrition, b) soil physical characteristics, c) soil biological characteristics, d) changes in crop yield, and e) environmental quality (e.g. erosion, runoff, and nutrient loss to water). Three questions were asked of survey participants targeting:

- Degree participant considers manure to benefit or harm each cropping system characteristic;
- Level of knowledge of participant for manure’s impact on each cropping system characteristic; and
- Level of knowledge of farmers with whom you interact of manure’s impact on each cropping system characteristic (asked only of those identifying as an advisor).

The degree to which those completing the survey rated manure as “beneficial” for crop fertility and nutrition was encouraging (Figure 6a). The crop fertility benefit was rated as “beneficial” by 92% of responses. Surveyed participants were also in general agreement of the benefit of manure for soil physical (73%) and biological (79%) as well as change in crop yield (69%). Prior to and during early implementation of US EPA’s National Pollution Discharge Elimination System and state permitting programs, manure management was commonly characterized as “waste management”. Manure has an extended history of being treated as a waste product. These results suggest that there may be a shift occurring in the perception of manure’s value.

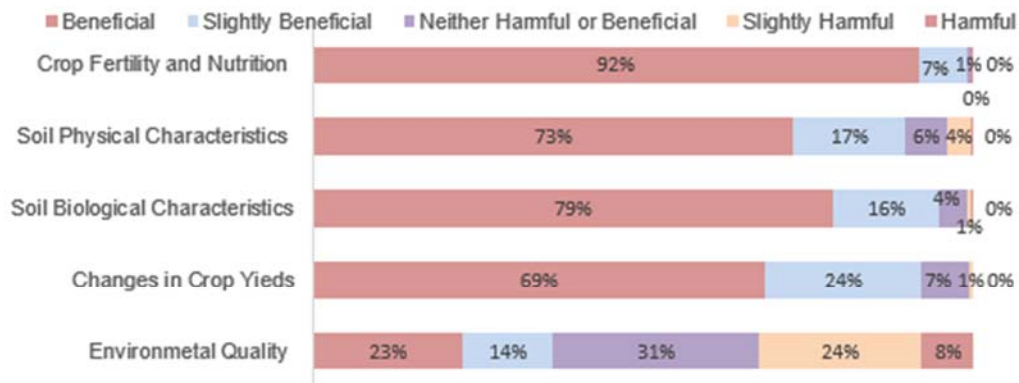
These perceptions of manure as a valued product provide a foundation upon which AFO’s and their advisors can promote the recycling of manure into fields with little or no history. This optimism should be tempered by recognition that those surveyed are biased towards use of manure. However, this does represent a farmer and advisor peer group supportive of manure’s value that may be influential for others in agriculture.

Environmental quality is described primarily as water quality in our survey (Figure 6a). A much smaller portion of those responding perceived manure as beneficial (23%) or slightly beneficial (14%). A slightly smaller group (32%) perceived manure as harmful or slightly harmful and the largest group (31%) labeled manure as neither harmful nor beneficial. Farmers are not likely making decisions on manure use based upon environmental quality. However, farmers and their advisors do not have the understanding or conviction to share information about manure’s potential benefits for reduced erosion, runoff, and reduced nutrient risks if manure is used according to good agronomic practices. Public policy at the state and local level continues to be influenced by negative environmental perceptions of animal manures. Manure users and technical advisors may not be prepared to share information counter to these perceptions. Thus, the negative

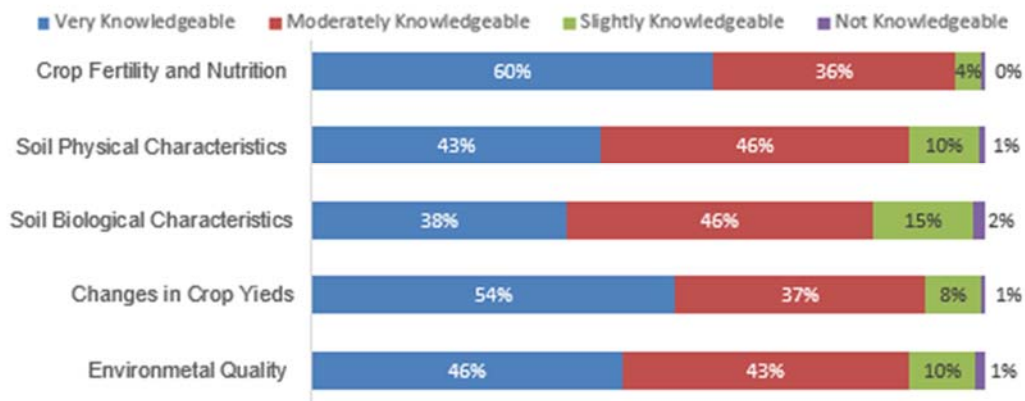
perception of manure's water quality risks continues to persist in rural communities further impeding its expanded recycling in cropland.

Relative to knowledge of these same Potential Benefits topics, those responding believe that they are either very to moderately knowledgeable (85% to 96%) relative to all five issues (Figure 6b). Somewhat surprising is that a similar level of knowledge was exhibited towards the environmental quality topic as other potential benefits. Recall that responses to the previous question relative to the environmental quality topic was almost equally split between those considering manure to be a benefit and harmful. Our assumption is that those surveyed may have a stronger understanding of some of the environmental harms that result from animal manures while possibly not having a similar understanding of environmental benefits. For the remaining four Potential Benefits evaluated, those surveyed indicate a positive impression of their knowledge on those benefits.

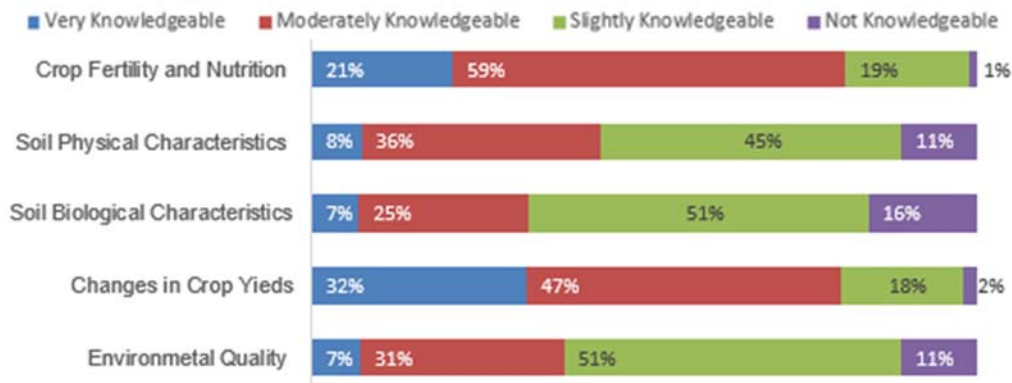
**a. Beneficial / Harmful: To what degree do you consider manure to benefit or harm these cropping system characteristics (n=802):**



**b. My Knowledge: How knowledgeable are you of manure's impact on the following (n=801):**



**c. Perception of Farmer Knowledge: How knowledgeable are the farmers with whom you interact of manure's impact on the following (n=560):**



**Figure 6. Perceptions and level of knowledge about factors commonly believed to offer benefits to crops or soils.**



Those who indicated that they are providing technical or advisory services were asked to further evaluate the knowledge of the farmers with who they interact (Figure 6c). The general rating of knowledge of crop farmers was significantly lower than survey participants rating of themselves. Understanding of manure's value to crop yields (79% rated as very or moderately knowledgeable) and crop fertility (80% rated as very or moderately knowledgeable) continued to demonstrate a higher level of skill. Ratings of knowledge of environmental quality (38% rated as very or moderately knowledgeable), soil biological characteristics (32% rated as very or moderately knowledgeable), and soil physical characteristics (44% rated as very or moderately knowledgeable) were all substantially lower. Advisors do not appear to have a very high opinion of the knowledge of crop farmers for soil and environmental quality topics.

## **Barriers to Manure Use**

The conversations with our stakeholder advisory group and others revealed a long list of potential challenges that may represent barriers to manure use in cropping systems. A critical purpose of our survey was to identify those challenges that are commonly identified as preventing manure use on some fields. We assembled a list of 33 challenges into five broad categories identified as 1) agronomic challenges, 2) economic challenges, 3) neighbor and rural community, 4) regulatory, and 5) logistical challenges.

A review of the top ten frequent barriers preventing manure use in some crop fields (see Table 1) revealed concerns from all five broad categories. This would suggest that those planning manure application to an individual field are balancing a broad array of challenges when considering manure application, any one of these challenges which may prevent manure's use. This provides some insight as to the challenge faced by animal feeding operations as they consider the potential for transferring manure to neighboring crop farms and their efforts to balance the environmental benefits with this transfer with the risks. Thus, the perceived imbalance of manure's benefits against the rather long list of potential risks is a likely reason why many fields are not receiving animal manures. A review of the top ten challenges follows.

*Economics:* Highest among these risks was an economic consideration related to the transportation and application costs of manure (90% of responses). An examination of the economic benefits versus costs is a highly critical conversation when considering the transfer to manure to more distant fields. An additional economic challenge just outside the top ten list addressed the initial cost of adding manure to the fertility program (46% of responses), likely associated with cost of equipment for transportation and application. Overcoming economic questions will be critical to expanded manure use.

*Neighbor and rural community* issues in the form of odors (78% of responses) was the next most common challenge. Although additional rural community issues did not make the top ten list, several of these issues including community concern with water quality impairment, active concerned citizens and increased traffic were identified by more than 40% of the survey responses. Minimizing odor impacts and possibly other rural community concerns need to be addresses for successful manure transfers.

*Logistical challenges:* Three logistical issue including timeliness of application (72%), field conditions limiting application (66%), and time/labor requirements (63%) were next in line as barriers to manure use. Crop farmers recognition of the importance to delivery of fertility products within the limited available windows of opportunity and limitations for timely manure application appears to be a critical hurdle to broader use of manures.

*Agronomic challenges* including soil compaction from application equipment (57%) and poor uniformity of nutrient application (51%) are significant impediments to expanded manure use. Two additional topics were just outside the top ten concerns including poor fit with reduced tillage (45%) and manure's N/P ratio (44%) were also common barriers. Manure's challenge with providing similar qualities as conventional fertilizer when the crop farmer weighs these two options appears to be a critical impediment to manure use on a broader scope.

*Regulations:* The level of current regulation of manure application practices such as setbacks was the only "regulatory challenge" top ten barrier (50%) identified by those surveyed. In addition, other regulatory challenges such as cost of regulatory compliance (43%) and local zoning restrictions for odor (41%) are additional possible barriers. When selecting between commercial fertilizers, frequently managed with few or no regulatory restrictions, versus manure, commonly perceived as highly regulated, crop farmers will frequently lean toward less government restrictions.

Few of the proposed challenges were not identified by at least one-third of the responses. Those challenges that were seldom identified matched well with the benefit previously identified for manure including limited value to soil health (4%), limited value to manure nutrients (13%), inability to replace fertilizer (14%) and likely yield decrease (5%). The

recognition that these topics are benefits of using manure in a crop fertility program provide some fundamental arguments for managing manure as a valued resource. These discussions are critical for offsetting the multiple barriers identified for manure use.

**Table 1. The following is a list of potential challenges to using manure in cropping systems and the regularity of these challenges being identified as a frequent barrier (either real or perceived) preventing manure use.**

Challenges		Count	%
Top Ten Challenges			
Economic	Transportation and application costs	693	90%
Neighbor	Odors	597	78%
Logistical	Timeliness of application	555	72%
Logistical	Field conditions limiting application	508	66%
Logistical	Time/labor requirements	486	63%
Agronomic	Application equipment compaction	435	57%
Agronomic	Poor uniformity of application	391	51%
Regulatory	Regulations	381	50%
Agronomic	Weed seed from manure	366	48%
Economic	Initial costs for adding manure	355	46%
Additional Challenges			
Neighbor	Water quality impairment	353	46%
Agronomic	Poor fit with reduced tillage	345	45%
Agronomic	Manure N to P Imbalance	337	44%
Neighbor	Active concerned citizens	334	43%
Regulatory	Regulatory compliance costs	329	43%
Regulatory	Local zoning - odor	317	41%
Neighbor	Increased traffic	312	41%
Logistical	Accessibility of custom applicators	278	36%
Neighbor	Manure stockpiles	273	36%
Neighbor	Damage to local infrastructure	267	35%
Regulatory	Local zoning water quality	265	35%
Economic	Cost of acquiring manure	258	34%
Logistical	Availability of manures	252	33%
Neighbor	Legal challenges by neighbors	248	32%
Neighbor	Flies	206	27%
Regulatory	Risks to food crops	154	20%
Logistical	Use of or crossing of public roads	146	19%
Agronomic	Inability to replace fertilizer	111	14%
Economic	Limited value of manure nutrients	97	13%
Agronomic	Foreign materials	91	12%
Economic	Poor crop yield	49	6%
Agronomic	Likely yield decrease	36	5%
Economic	Limited value to soil health	34	4%
		9859	responses

As part of the questions asked of all survey participants about perceived challenges, we explored manure's role in a crop fertility program relative to commercial fertilizer. The following question was asked:

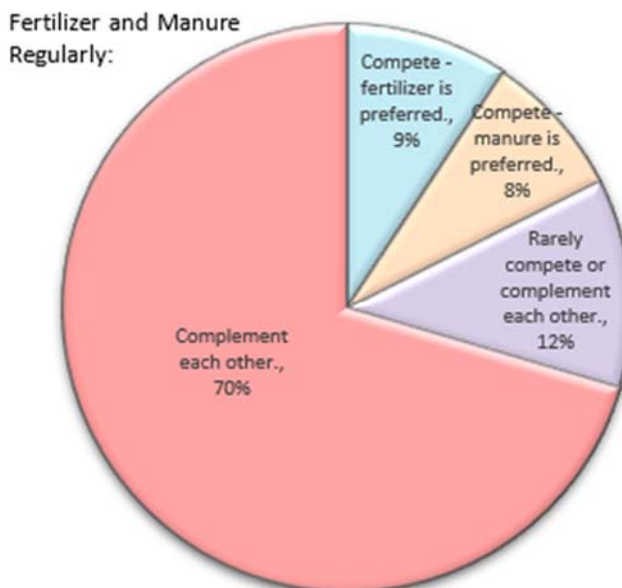
*Which of these statements do you personally believe is most true in your management decisions (or recommendations) with respect to use of manure and fertilizer in cropping programs?*

Four possible response options were included:

- Fertilizer and manure are regularly competing against each other in crop fertility programs with fertilizer typically being the preferred option.

- Fertilizer and manure are regularly competing against each other in crop fertility programs with manure typically being the preferred option.
- Fertilizer and manure are typically used independently and rarely are in competitive or complementary roles.
- Fertilizer and manure regularly complement each other in crop fertility programs.

The predominant response was that manure and fertilizer were perceived as regularly complementing each other in a crop fertility program (Figure 7). The complementary roles of fertilizer and manure have been documented by two meta-analysis studies. Xia's (et al., 2017) suggested the largest average yield increases (13% across all reporting studies) occurred for manure supplying 50 to 75% of nitrogen supplementation. Lin's (et al., 2018) review of poultry manure suggested the greatest yield increase of 18% was experienced where manure and fertilizer was co-applied. Recognition of the value of co-applying manure and fertilizer and the resulting potential yield benefits could be a powerful argument for expanding manure use in cropland with no previous history.



**Figure 7. Survey participants' responses to what they personally believe is most true in their management decisions (or recommendations) with respect to use of manure and fertilizer in cropping programs?**

## Implications and Applications

Our intent of this survey is to help our project team better target educational messages specific to the needs of the farmers and their advisors who may be considering manure use in the cropping systems. While additional review of responses specific to individual audiences will be beneficial, some initial ideas for future educational messages and targeted services important to manure's future use will be highlighted.

### Manure's Benefits

The agronomic and yield benefits of animal manures are reasonably well understood by those participating in this survey. Further efforts to build general awareness of these benefits may offer limited value. It is the authors' assumption that education and services may need to transition to more in-depth issues to assist AFO managers and advisors communicate specific messages such as:

- desirable rates/plans to best meet crop N and P needs and
- field-by-field estimation of manure's fertilizer replacement value including which nutrients contribute the greatest value.

A tabletop mapping education exercise (supported by North American Manure Expo) was piloted in 2020 engaging farmers in calculation of the economic return for individual fields from manure. The exercise demonstrated a substantial variability in manure's value to individual fields, a lack of awareness for cost of transporting manure longer distances, and a highly valued experience by the farmers completing these exercises. Services and education focused on maximizing manure's economic and agronomic benefits may deliver future value.

Farmers and their advisors appear to share a strong recognition of the value of manure to soil physical and biological properties. However, we received mixed messages on farmer's understanding of soil physical and biological properties. Possibly farmers recognize the benefits but are uncomfortable in communicating these benefits to others or less able to identify fields benefitting from soil health improvements. Our tabletop map exercise introduced farmers to three "soil health" measures to identify preferred fields for manure. Soil health measures were universally new to participants. However, farmers shared many observations about field characteristics they used to target for soil quality improvements. We anticipate that future educational programs connecting manure and soil health will be highly valued.

Farmers and their advisors all have very low opinions and understanding of manure's benefits to water quality. Few

appear to recognize the benefits of soil aggregation improvements potentially available for many soils and the resulting reductions in erosion and runoff. Equally likely is a low understanding of the value of manure N and P connected with organic compounds as compared the relatively mobile N and P forms in inorganic fertility. Our agricultural audiences have experienced substantial negative public and agricultural press describing the water quality risks from manure, generally associated with over application. There may be value in helping farmers articulate among themselves and to their rural communities the water quality benefits of organic fertilizers when applied to only meet agronomic needs of the crop. We may also need to re-evaluate negative implications of tools such as the P-Index to justify over-application of manure P.

We also learned that those who are frequent users of manure in their decisions or recommendations have come to recognize the complementary benefits of manure and fertilizer. The literature strongly supports this complementary role as the most significant opportunity for 10%+ yield increases. The potential for yield increases is a persuasive argument for moving manure into fields with no manure history. Agronomic education and advising that helps crop farmers define best practice complementary roles for manure and fertilizer are needed could be a smart strategy for expanding manure use among farmers with no history of manure use.

## **Manure's Barriers**

A wide range of challenges associated with animal manure use can prevent its acceptance for individual fields as well as derail agriculture's circular economy. Individual regions may need to further assess those regionally specific and audience specific challenges to best target local educational and service needs. However, the authors wish to suggest that four challenges commonly rise to the top and can serve as significant barriers to manure use.

*Transportation Costs:* The cost of transporting manure is barrier #1. Is this perception based upon an understanding of today's costs and services available? Businesses providing manure hauling and land application services have greatly expanded in the last decade in their availability and the ability to move large volumes across significant distances. Should one revisit how far manure can be hauled? Educational programs targeting the cost of moving manure and comparing with the value of manure to an individual field should be a future focus. In addition, growing those business services that engage in moving and applying manure and connecting crop farmer with livestock manure will be essential.

*Odor:* The unhappy calls received by farmers from neighbors about manure odors is a significant barrier for expanding manure use. Farmers' desire to be a good neighbor is counter to their willingness to create odors for their neighbors. Education and planning that targets practices for reducing odor risks must be targeted. Technology options for incorporating manure is one option. However, recognition that odors are a part of manure application, even with best practices in place, is crucial. Placing an emphasis on training farmers and manure haulers about conditions that lead to air inversions and odor concentration at ground level would be beneficial. Should farmers be able to review a weather forecasts before applying manure and pick preferred fields to receive manure? Should farmers receive an "Odor Forecast" predicting timing and wind direction when odor inversions are likely to occur?

*Logistical Barriers:* A range of logistical challenges ranked near the top as common barriers to using manure. Three logistical issues were among the top five challenges 1) timeliness of manure application, e) time/labor availability; 2) field conditions restricting manure application. Multiple next steps are essential for responding to logistical issues. As discussed previously, business services for transporting and land applying manure as well brokering manure transfer from AFO to crop farmer are essential. Helping farmers and manure haulers expand their manure application window, such as side dressing a crop with manure, will be valuable.

*Agronomic Issues:* Manure application comes with a history of agronomic concerns such as compaction, poor uniformity, and potential for weed seed and herbicide resistance concerns. Many agronomic issues are likely to be regionally specific and manure source specific, thus the need to adapt agronomic education to local needs. Education and business service strategies that encourage technologies such as precision manure application, towed-hose manure applicators, side-dressing of corn with manure, designer manures, and composting may have value based upon regional needs.

## **Summary**

A survey was completed with 957 crop farmers, animal feeding operation managers, and those providing technical services to farmers on crop fertility decisions including manure. An initial review of this data reveals:

- A strong recognition of manure's fertility, yield, and soil health benefits currently exists among these audiences. The strong recognition of the complementary roles of manure and fertilizer was also observed, a potentially strong argument for manure use by farmers with no previous manure experience. Agronomic and yield benefits appear to be well understood by most audiences. Soil health benefits of manure may be less well understood by farmers compared to fertility benefits.
- Manure's water quality benefits are not perceived to exist. Historical management of manure as a waste and the associated water quality challenges is a likely contributor to this negative perception. Farmers and their advisors do not perceive or are unable to articulate the value of improved soil aggregation resulting from manure (contributing to reduced runoff and erosion) or the water quality benefit of delivering nitrogen and phosphorus as an organic compound (varies depending on manure source) as opposed to a more mobile inorganic source.
- Many challenges associated with manure frequently become barriers to manure use. The group identified five challenges most likely to prevent manure recycling including 1) transportation costs, 2) odor, 3) logistical barriers, 4) agronomic questions about manure, and 5) perceptions of increased regulation with manure use. These barriers will need to be addressed if we are to expand manure's use in more cropland.
- If manure is to be utilized in a greater portion of our feed grain and forage production acres, education and business service need to be encouraged that articulate the benefits of manure and provide solutions for the critical barriers preventing manure use.
- This survey was influenced heavily by individual participants from the corn belt and high plains region of the U.S., by those in private sector advising roles, and farmers and advisors with a history of including manure in crop fertility plans. A more complete picture of benefits and barriers will be achieved as this survey is completed by a broader cross section of stakeholders connected to this issue.

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**Appendix A: Opening page of the Manure Use in Cropping Systems survey. The survey is accessible at <http://go.unl.edu/manure>.**

## Manure Use in Cropping Systems

We would like to better understand your views on the benefits and barriers that impact farmers' use of manure on cropland, and what issues are most important to you as you make decisions or advise on the use of manure in cropping systems. Your completion of this survey will help guide outreach programming efforts as our team develops manure management resources for farmers, Extension educators, NRCS staff, and crop advisors.

The survey will require 15 minutes or less to complete. Your decision whether or not to participate in this survey is voluntary and your responses will remain anonymous. You may ask any questions concerning this survey and have those questions answered before agreeing to participate in or during the survey. Please contact the investigators: Rick Koelsch ([rkoelsch1@unl.edu](mailto:rkoelsch1@unl.edu)), University of Nebraska-Lincoln; Sally Flis ([sflis@tfi.org](mailto:sflis@tfi.org)), The Fertilizer Institute with your questions.

### Survey Partners:



*Others providing leadership for this project include: Dan Andersen, Iowa State University; Erin Cortus and Melissa Wilson, University of Minnesota; and Leslie Johnson and Amy Schmidt, University of Nebraska-Lincoln. Funding for this project is provided by the USDA's North Central Region Sustainable Agriculture Research and Education (NC-SARE) Program (Rob Myers, NC-SARE Regional Coordinator and Director of Professional Development Programs, [myersrob@missouri.edu](mailto:myersrob@missouri.edu)).*

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